FORM PTO-1390
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US DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEYS DOCKET NUMBER
P-01,0300

JC11 Rec'd PCT/PTO SEP 2 4 2001

U.S.APPLICATION NO. (if known, see 37 CFR 1.5)
09/937290

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/DE00/00783	March 13, 2000	March 24, 1999

TITLE OF INVENTION "ORGANIC ELECTROLUMINESCENT COMPONENT"

APPLICANT(S) FOR DO/EO/US Andreas Kanitz and Matthias Stössel

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay.
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of International Application as filed (35 U.S.C. 371(c)(2))
   - a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
   - b. ☐ has been transmitted by the International Bureau.
   - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. §371(c)(3))
   - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   - b. ☐ have been transmitted by the International Bureau.
   - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   - d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98; **(PTO 1449, Prior Art, Search Report)**.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☒ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:
    - a. ☒ Submission of Drawings with Translations of German-Language Legends - 3 sheets
    - b. ☒ EXPRESS MAIL #EL843743118US dated September 24, 2001

JC16 Rec'd PCT/PTO SEP 2 4 2001

U.S. APPLICATION NO. (if known, see 37 C.F.R. 1.5) 09/937290	INTERNATIONAL APPLICATION NO. PCT/DE00/00783	ATTORNEY'S DOCKET NUMBER P-01,0300

17. ☒ The following fees are submitted:	CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5): Search Report has been prepared by the EPO or JPO .... $860.00 International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) ... $670.00 No international preliminary examination fee paid to USPTO (37 C.F.R. 1.482) but international search fee paid to USPTO (37 C.F.R. 1.445(a)(2) .... $760.00 Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search fee (37 C.F.R. 1.445(a)(2) paid to USPTO .... $970.00 International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) .... $ 96.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 860.00	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 C.F.R. 1.492(e)).	$	

Claims	Number Filed		Number Extra	Rate		
Total Claims	18	- 20 =	0	X $18.00	$	
Independent Claims	1	- 3 =	0	X $80.00	$	
Multiple Dependent Claims				$270.00 +	$	
TOTAL OF ABOVE CALCULATIONS =					$ 860.00	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 C.F.R. 1.9, 1.27, 1.28)					$	
SUBTOTAL =					$ 860.00	
Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +					$	
TOTAL NATIONAL FEE =					$ 860.00	
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). $40.00 per property +						
TOTAL FEES ENCLOSED =					$ 860.00	
					Amount to be refunded	$
					charged	$

a. ☒ A check in the amount of $860.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. __________ in the amount of $ _______ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 501519. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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JC16 Rec'd PCT/PTO SEP 2 4 2001

IN THE UNITED STATES ELECTED OFFICE OF THE UNITED STATES PATENT AND TRADEMARK OFFICE UNDER THE PATENT COOPERATION TREATY - CHAPTER II

SUBMISSION OF DRAWINGS WITH TRANSLATIONS OF GERMAN-LANGUAGE LEGENDS

APPLICANTS: Andreas Kanitz and Matthias Stössel

ATTORNEY DOCKET NO.: P-01,0300

SERIAL NO.: EXAMINER:

FILING DATE: ART UNIT:

INTERNATIONAL APPLICATION NO.: PCT/DE00/00783

INTERNATIONAL FILING DATE: 13 March 2000

INVENTION: "ORGANIC ELECTROLUMINESCENT COMPONENT"

BOX PCT
Assistant Commissioner for Patents
Washington, D.C. 20231

SIR:

Attached herewith are three sheets of drawings containing Figs. 1-5, with the legends on the graphs of Figs. 3, 4 and 5 being provided with translations.

Respectfully submitted,

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DATED: September 24, 2001

IN THE UNITED STATES ELECTED OFFICE OF THE UNITED STATES PATENT AND TRADEMARK OFFICE UNDER THE PATENT COOPERATION TREATY - CHAPTER II

PRELIMINARY AMENDMENT

APPLICANTS: Andreas Kanitz and Matthias Stössel

ATTORNEY DOCKET NO.: P-01,0300

SERIAL NO.: EXAMINER:

FILING DATE: ART UNIT:

INTERNATIONAL APPLICATION NO.: PCT/DE00/00783

INTERNATIONAL FILING DATE: 13 March 2000

INVENTION: "ORGANIC ELECTROLUMINESCENT COMPONENT"

BOX PCT
Assistant Commissioner for Patents
Washington, D.C. 20231

SIR:

Please amend the above-identified International Application before entry into the National Stage before the U.S. Patent and Trademark Office under 35 USC 371 as follows:

IN THE SPECIFICATION:

Please replace pages 1-15 with the attached Substitute Specification.

IN THE ABSTRACT OF THE DISCLOSURE:

Please replace the Abstract with the attached unnumbered page containing the Abstract of the Disclosure.

IN THE CLAIMS:

Please cancel claims 1-10, without prejudice.

Please add the following claims.

--11. An organic electroluminescent component for an organic light-emitting diode, said component comprising:

a transparent bottom electrode situated on a substrate;

a top electrode composed of a metal that is inert to oxygen and moisture;

at least one organic function layer arranged between the bottom electrode and the top electrode; and

a charge carrier injection layer containing a complex metal salt of the composition $(Me1)(Me2)F_{m+n}$, whereby the following applies:

m and n are respectively a whole number corresponding to the valence of the metals Me1 and Me2 with the metal Me1 having the valence m, the metal Me2 having the valence n,

Me1 being a metal selected from a group consisting of Li, Na, K, Mg and Ca,

Me2 being a metal selected from a group consisting of Mg, Al, Ca, Zn, Ag, Sb, Ba, Sm and Yb,

with the prescription: Me1 $\neq$ Me2.--

--12. An organic electroluminescent component according to claim 11, wherein the top electrode is composed of a metal selected from a group consisting of aluminum, silver, platinum and gold and of an alloy of two of these metals.--

--13. An organic electroluminescent component according to claim 12, wherein the charge carrier injection layer is arranged between the top electrode and the uppermost organic function layer.--

--14. An organic electroluminescent component according to claim 13, wherein the charge carrier injection layer comprises a thickness between 0.1nm and 20nm.--

--15. An organic electroluminescent component according to claim 14, wherein the metal Me1 is lithium and the metal Me2 is selected from magnesium, aluminum, calcium, silver and barium.--

--16. An organic electroluminescent component according to claim 15, wherein the complex metal salt is a salt selected from $LiAlF_4$, $LiAgF_2$ and $LiBaF_3$.--

--17. An organic electroluminescent component according to claim 16, wherein two organic function layers are arranged between the bottom electrode and the top electrode, wherein an apertured conducting layer is located on the bottom electrode and an emission layer is located on said conducting layer.--

--18. An organic electroluminescent component according to claim 17, wherein the apertured conducting layer contains a material selected from N,N'-bis-(3-methylphenyl)-N,N'-bis(phenyl)-benzidine; 4,4',4"-tris-(N-1-napthyl-N-phenylamino)-triphenylamine; and N,N'-bis-phenyl-N,N'-bis-α-naphthyl-benzidine and the emission layer is a hydroxychinoline aluminum-III salt.--

--19. An organic electroluminescent component according to claim 18, wherein the bottom electrode is composed of indium tin oxide.--

--20. An organic electroluminescent component according to claim 19, wherein an electron transport layer is arranged on the at least one organic function layer.--

--21. An organic electroluminescent component according to claim 11, wherein the charge carrier injection layer is arranged between the top electrode and an uppermost organic function layer.--

--22. An organic electroluminescent component according to claim 11, wherein the charge carrier injection layer comprises a thickness between 0.1nm and 20nm.--

--23. An organic electroluminescent component according to claim 11, wherein the metal Me1 is lithium and the metal Me2 is selected from magnesium, aluminum, calcium, silver and barium.--

--24. An organic electroluminescent component according to claim 23, wherein the complex metal salt is selected from $LiAlF_4$, $LiAgF_2$ and $LiBaF_3$.--

--25. An organic electroluminescent component according to claim 11, wherein two organic function layers are arranged between the bottom electrode and the top electrode, whereby an apertured conducting layer is located on the bottom electrode and an emission layer is located on said conducting layer.--

--26. An organic electroluminescent component according to claim 25, wherein the apertured conducting layer is a material selected from N,N'-bis-(3-methylphenyl)-N,N'-bis(phenyl)-benzidine; 4,4',4"-tris-(N-1-naphthyl-N-

phenylamino)-triphenylamine and N,N'-bis-phenyl-N,N'-bis-α-naphthyl-benzidine and the emission layer is hydroxychinoline aluminum-III salt.--

--27. An organic electroluminescent component according to claim 11, wherein the bottom electrode is composed of indium tin oxide.--

--28. An organic electroluminescent component according to claim 11, wherein an electron transport layer is arranged on the at least one organic function layer.--

REMARKS

Claims 11-28 are presented for examination.

By this amendment, the translation of the PCT Application has been amended, with the amendments being incorporated in the attached Substitute Specification. A marked-up copy of the translation of the specification showing changes made is also attached. Also attached herewith on an unnumbered page is a new Abstract of the Disclosure. A marked-up copy of the Abstract is also attached. Claims 1-10 have been cancelled and new claims 11-28 have been submitted, which have been carefully drafted to remove multiple-dependency and to be in U.S. form.

Respectfully submitted,

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ABSTRACT OF THE DISCLOSURE

The organic electroluminescent component of the invention has a transparent bottom electrode situated on a substrate; a top electrode composed of a metal that is inert to oxygen and moisture; at least one organic function layer arranged between the bottom electrode and the top electrode; and a charge carrier injection layer containing a complex metal salt of the composition (Me1) (Me2)F_{m+n}, whereby the following applies:

m and n are respectively a whole number corresponding to the valence of the metals Me1 and Me2 (the metal Me1 thereby has the valence m, the metal Me2 the valence n),

Me1 is selected from a group consisting of Li, Na, K, Mg and Ca,

Me2 is selected from a group consisting of Mg, Al, Ca, Zn, Ag, Sb, Ba, Sm and Yb,

with the prescription: Me1 $\neq$ Me2.

Appendix

Title

ORGANIC ELECTROLUMINESCENT COMPONENT

Background of the Invention

The invention is directed to an organic electroluminescent component, particularly an organic light-emitting diode.

The visualization of data is constantly increasing in significance due to the great increase in the amount of information. The technology of flat picture screens ("flat panel displays") was developed therefor for employment in mobile and portable electronic devices. The market of flat panel displays is currently largely dominated by the technology of liquid crystal displays (LC displays). In addition to cost-beneficial manufacture, low electrical power consumption, low weight and slight space requirement, however, the technology of LC displays also exhibits serious disadvantages.

LC displays are not self-emitting and can therefore only be easily read or recognized given especially beneficial ambient light conditions. This makes a back-illumination device necessary in most instances, but this multiplies the thickness of the flat panel display. Moreover, the majority part of the electrical power consumption of the display is then needed for the illumination, and a higher voltage is required for the operation of the lamps or fluorescent tubes~~; this~~, which high voltage is usually generated from batteries or accumulators with the assistance of "voltage-up converters". Other disadvantages are the highly limited observation angles of LC displays and the long switching times of individual pixels, ~~these typically lying at~~ which switching times typically lie a few milliseconds and also ~~being~~ are highly temperature-dependent. The delayed image build-up is considered extremely disturbing, for example, given utilization in means of conveyance or given video applications.

There are other flat panel display technologies in addition to LC displays, for example the technology of flat display panel cathode ray tubes, of vacuum-fluorescence displays and of inorganic thin-film electroluminescent displays. ~~These~~ However, either there technologies~~, however,~~ have ~~either~~ not yet achieved the required degree of technological maturity or -- due to high operating voltages or, respectively, high

manufacturing costs -- they are only conditionally suited for utilization in portable electronic devices.

Displays on the basis of organic light-emitting diodes, which are called OLEDs, ~~(≡OLEDs)~~ do not exhibit ~~said~~ these disadvantages. The necessity of a back-illumination is eliminated due to the self-emissivity, as a result whereof the space requirement and the electrical power consumption are considerably reduced. The switching times lie at about one microsecond and are only slightly temperature-dependent, which enables employment for video applications. The reading angle amounts to nearly 180°, and polarization films ~~as~~ that are required given LC displays are eliminated, so that a greater brightness of the display elements can be achieved. Further advantages are the employability of flexible and non-planar substrates as well as a simple and cost-beneficial manufacture.

The construction of organic light-emitting diodes typically ensues in the following way.

A transparent substrate, for example glass, is coated with a transparent electrode (bottom electrode, anode), composed, for example, of indium tin oxide (ITO). Dependent on the application, the transparent electrode is then structured with the assistance of a photolithographic process.

One or more organic layers composed of polymers, oligomers, low-molecular compounds or mixtures thereof are applied on the substrate with the structured electrode. Examples of polymers are polyaniline, poly(p-phenylene-vinylene) and poly(2-methoxy-5-(2'-ethyl)-hexyloxy-p-phenylene-vinylene). Examples of low-molecular compounds that preferably transport positive charge carriers are N,N'-bis-(3-methylphenyl)-N,N'-bis-(phenyl)-benzidine (m-TPD), 4,4',4"-tris-(N-3-methylphenyl-N-phenyl-amino)-triphenylamine (m-MTDATA) and 4,4',4"-tris-(carbazole-9-yl)-triphenylamine (TCTA). Hydroxy-chinoline aluminum-III salt (Alq_3) that can be doped with suitable chromophores (chinacridone derivatives, aromatic hydrocarbons, etc.), for example, is employed as an emitter. As warranted, additional substances that influence the electro-optical and the long-term properties, such as copper phthalocyanine, can be present. The application of polymers usually ensues from the liquid phase with doctor blades or spin-coating; low-molecular and

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oligomeric compounds are usually deposited from the vapor phase by vapor deposition or "physical vapor deposition" (PVD). The overall layer thickness can amount to between 10 nm and 10 μm and it typically lies in the range between 50 and 200 nm.

A cooperating electrode (top electrode, cathode), which is usually composed of a metal, of a metal alloy or of a thin insulator layer and a thick metal layer, is applied onto the organic layer or layers. The manufacture of the cathode layer usually ensues with vapor phase deposition by means of thermal evaporation, electron beam evaporation or sputtering.

When metals are employed as cathode material, then these must have a low work function (typically < 3.7 eV) so that electrons can be efficiently injected into the organic semiconductor. Alkaline metals, alkaline earth metals or rare earth metals are usually employed for this purpose and the layer thickness lies between 0.2 nm and a few hundred nanometers but generally at a few 10 nanometers. Since, however, these non-precious metals tend toward corrosion under atmospheric conditions, it is necessary to additionally apply a layer of a more precious, inert metal such as aluminum (Al), copper (Cu), silver (Ag) or gold (Au) onto the cathode layer that protects the non-precious metal layer against moisture and atmospheric oxygen.

For increasing the stability of the cathodes against a corrosion-caused hole formation, an alloy composed of an efficiently electron-injecting but corrosion-susceptible non-precious metal (work function < 3.7 eV) and a corrosion-resistant or precious metal, such as Al, Cu, Ag and Au, is often employed instead of an unalloyed non-precious metal. The proportion of the non-precious metal in the alloy can amount to between a few tenths of a percent and approximately 90%. The alloys are usually generated by simultaneous deposition of the metals from the vapor phase, for example by co-vapor deposition, simultaneous sputtering with a plurality of sources and sputtering upon employment of alloy targets. However, a layer of a precious metal or corrosion-resistant metal such as Al, Cu, Ag or Au, is usually also additionally applied onto such cathodes as protection against corrosion.

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Cathodes composed of precious metals, i.e. metals having a work function > 3.7 eV, are very inefficient electron injectors when they are utilized in direct contact with the organic semiconductor. When, however, a thin insulating intermediate layer (layer thickness generally between 0.2 and 5 nm) is arranged between the uppermost, electron-conducting organic layer and the metal electrode, then the efficiency of the light-emitting diodes rises substantially. Oxides such as aluminum oxide, alkaline and alkaline earth oxides and other oxides as well as alkaline and alkaline earth fluorides come into consideration as the insulating material for such an intermediate layer (in this respect, see Appl. Phys. Lett., Vol. 71 (1997), pages 2560 through 2562; United States Letters Patent 5,677,572; European Published Application 0 822 603). A metal electrode that is composed of a pure metal or of a metal alloy is then applied onto the thin, insulating intermediate layer. The insulating material can thereby also be applied together with the electrode material by means of co-vapor deposition (Appl. Phys. Lett., Vol. 73 (1998), pages 1185 through 1187).

Summary of the Invention.

An object of the invention is to fashion an organic electroluminescent component, particularly an organic light-emitting diode, such that, on the one hand, a hermetic seal of the top electrode can be foregone and, on the other hand, the selection of materials employable at the cathode side is greater.

This is inventively achieved by a component that ~~is characterized by~~ comprises

-- a transparent bottom electrode situated on a substrate;

-- a top electrode composed of a metal that is inert to oxygen and moisture;

-- at least one organic function layer arranged between the bottom electrode and the top electrode; and

-- a charge carrier injection layer containing a complex metal salt of the composition (Me1) $(Me2)F_{m+n}$, whereby the following applies:

m and n are respectively a whole number corresponding to the valence of the metals Me1 and Me2 (the metal Me1 thereby has the valence m, the metal Me2 the valence n),

Me1 ~~=~~ is selected from a group consisting of Li, Na, K, Mg ~~or Ca~~, and Ca

Me2 ~~=~~ is selected from a group consisting of Mg, Al, Ca, Zn, Ag, Sb, Ba, Sm ~~or~~ and Yb,

with the prescription: Me1 $\neq$ Me2.

The critical feature of the organic electroluminescent component of the invention is thus ~~comprised~~ in a specific structure at the cathode side, namely in the combination of a top electrode that is indifferent with respect to environmental influences with a charge carrier injection layer composed of a specific complex metal salt having the composition (Me1) (Me2)F_{m+n}, i.e. a double fluoride. As a result of this structure, a hermetic seal or, respectively, sealing of the top electrode can be omitted. As a result of the specific material for the charge carrier injection layer, not only is the offering for the materials employable at the cathode side broadened, this material also achieves an improvement of the emission properties, which are expressed in a clearly higher light yield, a reduced operating voltage and a longer service life during operation.

The charge carrier injection layer (composed of a specific complex metal salt) is preferably arranged as a thin insulating layer either between the top electrode and the organic function layer~~,~~ or between the uppermost function layer and the top electrode given the presence of a plurality of function layers. When an electron transport layer is also additionally located on the (uppermost) function layer given the component of the invention, then the charge carrier injection layer is arranged between this transport layer and the top electrode. In all of these instances, the thickness of the charge carrier injection layer preferably amounts to approximately 0.1 through 20 nm.

However, the charge carrier injection layer can also be quasi-integrated into the top electrode, into the (uppermost) organic function layer or into an electron transport layer that is potentially present, i.e. the complex metal salt is then a constituent part of one of ~~said~~ these layers. The production of such layers can advantageously ensue by means of co-vapor deposition of the corresponding materials, for example by co-vapor deposition of the top electrode material and of the complex metal salt.

MARKED-UP VERSION

The complex metal salt exhibits the composition (Me1) (Me2)F_{m+n}, whereby m and n correspond to the valence of the respective metal. m = 1 (Li, Na, K) or m = 2 (Mg, Ca) is valid for Me1; n = 1 (Ag) or n = 2 (Mg, Ca, Zn, Ba) or n = 3 (Al, Sb, Sm, Yb) is valid for Me2. The metal Me1 is preferably lithium (Li); the metal Me2 is preferably magnesium (Mg), aluminum (Al), calcium (Ca), silver (Ag) or Barium (Ba).

Advantageously, one of the double fluorides $LiAgF_2$, $LiBaF_3$ and $LiAlF_4$ is employed as the complex metal salt. More such double fluorides are, for example, $NaAgF_2$, $KAgF_2$, $LiMgF_3$, $LiCaF_3$, $CaAgF_3$ and $MgBaF_4$. Complex salts of this type as well as methods for manufacturing them are known in and of themselves (in this respect, see the exemplary embodiments as well as, for example, "Gmelins Handbuch der Anorganischen Chemie", 8th Edition (1926), System Number 5 (fluorine), pages 58 through 72).

The top electrode, which generally comprises a thickness > 100 nm, is preferably composed of one of the following metals: aluminum (Al), silver (Ag), platinum (Pt) and gold (Au). The electrode material, however, can also be an alloy of two of these metals. Magnesium (Mg), calcium (Ca), zinc (Zn), antimony (Sb) and barium (Ba) come into consideration as other ~~further~~ metals for the top electrode.

The bottom electrode is generally composed of indium tin oxide (ITO). Other ~~Further~~ possible materials for the bottom electrode are tin oxide and bismuth oxide. Glass generally serves as the substrate for the bottom electrode.

The component of the invention preferably comprises two organic function layers, namely an apertured conducting layer arranged at the bottom electrode that transports positive charge carriers and an emission layer situated thereon that is also referred to as the luminescence layer. Two or more apertured conducting layers can also be advantageously utilized instead of one apertured conducting layer.

The materials for these ~~said~~ layers are known in and of themselves. In the present case, N,N'-bis-(3-methylphenyl)-N,N'-bis(phenyl)-benzidine (m-TPD), 4,4',4"-tris-(N-1-naphthyl-N-phenylamino)-triphenylamine (naphdata) or N,N'-bis-phenyl-N,N'-bis-α-naphthyl-benzidine (α-NPD) is preferably employed for the

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apertured conducting layer or layers. The material for the emission layer is preferably hydroxychinoline aluminum-III salt (Alq_3). Simultaneously, this material can also serve for the electron transport. For example, chinacridone can also be utilized for the emission layer, and one of the oxadiazole derivatives known for this purpose for a potentially present electron transport layer.

The invention offers the following, ~~further~~ additional advantages, particularly in view of organic light-emitting diodes:

-- Facilitated Handling

Due to the stability of the material of the top electrode, work need not be carried out under an inert gas atmosphere in the manufacture and further-processing of OLEDs.

-- Performance

Compared to top electrodes of non-precious metals, the operating voltage is clearly lowered and the light yield and efficiency are considerably enhanced.

-- Improved Properties

Compared, for example, to LiF as the material for the intermediate layer, compounds such as $LiAlF_4$ have the advantage that they are less hygroscopic, which facilitates the handling and storage. The double fluorides are also easier to evaporate and are less basic (than LiF), as a result whereof the compatibility with the organic function layers is increased.

The invention shall be explained in still greater detail on the basis of exemplary embodiments and Figures.

Brief Description of the Drawings

~~Shown are:~~

Figure 1 is a diagrammatic view of a traditional OLED display;

Figure 2 is a diagrammatic view of an OLED display of the invention;

Figure 3 is a graph showing luminance/voltage characteristics;

Figure 4 is a graph showing efficiency/luminance characteristics; and

Figure 5 is a graph showing a comparison of the luminance of various materials.

Description of the Preferred Embodiments

Example 1

Production of lithium aluminum fluoride $LiAlF_4$

Lithium aluminum hydride $LiAlH_4$ is carefully hydrolyzed with distilled water, and conversion is subsequently undertaken with hydrofluoric acid (HF) being in excess. The complex metal salt $LiAlF_4$ that thereby precipitates out is extracted, repeatedly washed with water and ethanol and then dried.

Example 2

Production of lithium silver fluoride $LiAgF_2$

A solution of stoichiometric quantities of lithium hydroxide and silver acetate is glacial acetic acid is converted with hydrofluoric acid (HF) being in excess upon exclusion of light and the complex metal salt $LiAgF_2$ thereby precipitates out. The complex salt is extracted after the addition of the same volume of ethanol, is washed with ethanol and dried.

Example 3

Production of lithium barium fluoride $LiBa_3$

An aqueous solution of stoichiometric quantities of lithium hydroxide and barium hydroxide is converted with hydrofluoric acid (HF) being in excess. The complex metal salt $LiBaF_3$ precipitates out when chilled (cooling with ice) and it is extracted, repeatedly washed with ethanol and then dried.

The complex metal salt $LiCaF_3$ is produced in a corresponding way, whereby the reaction solution is constricted as warranted.

The complex metal salt $LiMgF_3$ can be produced in the same way and lithium methylate and magnesium methylate are then utilized as the initial substances.

Example 4

Manufacture of a traditional OLED display ~~(10)~~ 10 with a Mg/Ag cathode (see Figure 1)

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An ITO layer ~~(12)~~ 12 having a thickness of approximately 100 nm is applied onto a glass substrate ~~(11)~~ 11. This layer is then photolithographically structured in such a way that a stripe-shaped structure ~~arises~~ is produced. A layer 13 of m-TPD ~~(13)~~ having a thickness of approximately 100 nm is first applied by thermal evaporation onto the coated substrate pre-treated in this way, followed by a layer ~~(14)~~ 14 of Alq_3 having a thickness of approximately 65 nm.

A layer ~~(15)~~ 15 of a magnesium-silver alloy (Mg:Ag mixing ratio 10:1) having a thickness of approximately 150 nm is applied onto the organic layer ~~(14)~~ 14 by thermal evaporation with two simultaneously operated evaporator sources, and a layer ~~(16)~~ 16 of pure silver having a thickness of approximately 150 nm is applied on ~~said~~ the layer ~~(15)~~ 15, likewise by thermal evaporation. The metal layers are thereby vapor-deposited through a mask with stripe-shaped openings, so that cathode stripes that lie perpendicular to the ITO stripes ~~arise~~ are produced. Organic light-emitting diodes with an active area of 2 x 2 mm^2 respectively ~~arise~~ are produced in this way at the intersections of the ITO tracks with the metal tracks -- together with the organic layers lying therebetween. During operation, the ITO layer is positively contacted~~;~~ and the metal tracks are negatively contacted.

<u>Example 5</u>

Manufacture of an OLED display ~~(20)~~ 20 of the invention (see Figure 2)

An ITO layer ~~(22)~~ 22 having a thickness of approximately 100 nm is applied onto a glass substrate ~~(21)~~ 21. This layer is then photolithographically structured in such a way that a stripe-shaped structure ~~arises~~ is produced. A layer 23 of m-TPD ~~(23)~~ having a thickness of approximately 100 nm is first applied by thermal evaporation onto the coated substrate pre-treated in this way, followed by a layer ~~(24)~~ 24 of Alq_3 having a thickness of approximately 65 nm.

A layer ~~(25)~~ 25 of $LiAlF_4$ having a thickness of approximately 1 nm is applied by thermal evaporation onto the ~~organic~~ layer ~~(24)~~ 24, and a layer ~~(26)~~ 26 of aluminum -- serving as a ~~top~~ electrode -- having a thickness of approximately 150 nm is applied onto said layer ~~(25)~~ 25, likewise by thermal evaporation. The two layers are

thereby vapor-deposited through a mask with stripe-shaped openings, corresponding to Example 4, so that organic light-emitting diodes ~~arise~~ are produced. During operation, the ITO layer is positively contacted~~,~~ and the top electrode is negatively contacted.

The results of measurements at the OLEDs corresponding to Examples 4 and 5 are compiled in Table 1. The threshold voltage (of the electroluminescence), the voltage and the efficiency (respectively given a luminance of 1500 cd/m^2), the maximum luminance and the luminance given a current density of 50 mA/cm^2) are thereby recited as characteristic data.

Table 1

Example	Threshold voltage [V]	Voltage [V] at 1500 cd/m^3	Efficiency [lm/W] at 1500 cd/m^2	Maximum luminance [cd/m^2]	Luminance [cd/m^2] at 50 mA/cm^2
4	2.08	14.48	0.677	15957	1544
5	1.87	14.12	0.720	18801	1605

It can be seen that the threshold voltage and the operating voltage of the display of the invention (Example 5) lie below the corresponding values given the traditional display (Example 4), even though the thickness of the $LiAlF_4$ was not optimized. The values for the efficiency and the luminances that are achieved given the display of the invention lie above the corresponding values of the traditional display.

Figure 3 shows the luminance/voltage characteristics of the displays according to Examples 4 and 5. The increased luminance of the display of the invention can be clearly seem from this illustration.

The following can be stated overall:

-- The display of the invention (Example 5) employs a cathode of aluminum with which efficiencies are normally achieved that lie approximately 40 to 50% below the corresponding values given Mg/Ag cathodes (Example 4). Aluminum, on the other hand, is more stable than magnesium vis a vis environmental influences such as atmospheric oxygen and moisture.

MARKED-UP VERSION

-- Due to the introduction of a thin $LiAlF_4$ between the organic function layers and the Al cathode, however, the efficiency of OLEDs having an Al cathode can be increased, namely even above the corresponding values of OLEDs with Mg/Ag cathode. In this way, high-efficiency OLEDs with stable cathode can be constructed.

Example 6

Manufacture of an OLED display with a Mg/Ag cathode

An ITO layer having a thickness of approximately 100 nm is applied onto a glass substrate. This layer is then photolithographically structured in such a way that a stripe-shaped structure is produced. ~~arises~~. A layer of naphdata having a thickness of approximately 55 nm is first applied by thermal evaporation onto the coated substrate pre-treated in this way, followed by a layer of α-NPD having a thickness of approximately 5 nm, and, finally, a layer of Alq_3 having a thickness of approximately 65 nm.

A layer of a magnesium-silver alloy (Mg:Ag mixing ratio 10:1) having a thickness of approximately 150 nm is applied onto the uppermost organic layer (of Alq_3) by thermal evaporation with two simultaneously operated evaporator sources, and a layer of pure silver having a thickness of approximately 150 nm is applied on the ~~said~~ uppermost organic layer, likewise by thermal evaporation. The metal layers are thereby vapor-deposited through a mask with stripe-shaped openings, so that cathode stripes that lie perpendicular to the ITO stripes are produced. ~~arise~~. Organic light-emitting diodes with an active area of 2 x 2 mm^2 respectively are produced ~~arise~~ in this way at the intersections of the ITO tracks with the metal tracks -- together with the organic layers lying therebetween. During operation, the ITO layer is positively contacted and the metal tracks are negatively contacted.

MARKED-UP VERSION

Example 7

Manufacture of an OLED display with an Al cathode

Corresponding to Example 6, a display having three organic function layers is constructed. A layer of aluminum having a thickness of 150 nm is then applied in a corresponding way by thermal evaporation onto the uppermost organic layer (of Alq_3).

Example 8

Manufacture of an OLED display with an Al cathode and an LiF intermediate layer

A display with three organic function layers is constructed corresponding to Example 6. A layer of LiF having a thickness of approximately 0.5 nm is then applied onto the uppermost organic layer (of Alq_3) by thermal evaporation, and a layer of aluminum having a thickness of approximately 150 nm is applied on ~~said~~ the uppermost organic layer. The two layers are thereby vapor-deposited through a mask having stripe-shaped openings in conformity with Example 6, so that organic light-emitting diodes ~~arise~~ are produced. During operation, the ITO layer is positively contacted, and the Al cathode is negatively contacted.

Example 9

Manufacture of an OLED display with an Al cathode and a $LiAlF_4$ charge carrier injection layer

A display with three organic function layers is constructed corresponding to Example 8. A layer of $LiAlF_4$ having a thickness of approximately 0.5 nm is then applied by thermal evaporation onto the uppermost organic layer (of Alq_3), and a layer of aluminum -- serving as top electrode -- having a thickness of approximately 150 nm is applied onto ~~said~~ the $LiAlF_4$ layer, likewise by thermal evaporation. The structuring and the contacting ensue in conformity with Example 8.

MARKED-UP VERSION

Example 10

Manufacture of an OLED display with an Al cathode and a $LiAgF_2$ charge carrier injection layer

A display with three organic function layers is constructed corresponding to Example 6. A layer of $LiAgF_2$ having a thickness of approximately 0.5 nm is then applied by thermal evaporation onto the uppermost organic layer (of Alq_3), and a layer of aluminum -- serving as a top electrode -- having a thickness of approximately 150 nm is applied onto said $LiAlF_4$ layer, likewise by thermal evaporation. The structuring and the contacting ensue in conformity with Example 8.

Example 11

Manufacture of an OLED display with an Al cathode and a $LiBaF_3$ charge carrier injection layer

A display with three organic function layers is constructed corresponding to Example 6. A layer of $LiBaF_3$ having a thickness of approximately 0.5 nm is then applied by thermal evaporation onto the uppermost organic layer (of Alq_3), and a layer of aluminum -- serving as a top electrode -- having a thickness of approximately 150 nm is applied onto ~~said~~ the $LiAlF_4$ layer, likewise by thermal evaporation. The structuring and the contacting ensue in conformity with Example 8.

The results of measurements at the OLEDs corresponding to Examples 6 through 11 are compiled in Table 2. The threshold voltage (of the electroluminescence), the voltage and the efficiency (respectively given a luminance of 1500 cd/m^2), the maximum luminance and the luminance given a current density of 50 mA/cm^2) are thereby recited as characteristic data.

Table 2

Example	Threshold voltage [V]	Voltage [V] at 1500 cd/m^3	Efficiency [lm/W] at 1500 cd/m^2	Luminance [cd/m^2] at 50 mA/cm^2
6	3.19	9.96	1.08	1722
7	7.15	16.52	0.48	1275
8	3.17	9.47	1.19	1809
9	4.23	11.97	0.88	1684
10	3.49	10.86	1.00	1745
11	2.56	9.58	1.26	1948

It can be seen that the threshold voltages and the operating voltages of the displays of the invention (Examples 9 through 11) that comprise an Al cathode and a charge carrier injection layer composed of a complex metal salt are comparable to the values that are obtained given displays with a Mg/Ag cathode or, respectively, with an Al cathode and a LiF intermediate layer (Examples 6 and 8) and lie clearly below the corresponding values given a display with a pure Al cathode (Example 7). The displays of the invention are also comparable to the Mg/Ag and Al-LiF displays in view of the efficiency and the luminance, whereby a display with a $LiBaF_3$ charge carrier injection layer (Example 11), in particular, exhibits high values.

Figure 4 shows the efficiency/luminance characteristics of the Examples 6 through 11. In particular, the superior position of an Al-$LiBaF_3$ of the invention can be clearly seen from this illustration.

It can be stated overall that the efficiency of LEDs with an Al cathode can be boosted above the corresponding values of OLEDs with a Mg/Ag cathode by introducing thin layers of a complex metal salt such as $LiAlF_4$, $LiAgF_2$ and $LiBaF_3$ between the organic function layers and the cathode. High-efficiency OLEDS with stable contact can be constructed in this way.

The values for the luminance (given a current density of 50 mA/cm^2) of the materials according to Examples 6 through 11 are compared to one another in Figure 5. The good results that can be achieved with the displays of the invention also can be derived ~~derive~~ therefrom.

We claim:
~~Patent Claims~~

1. Organic electroluminescent component, particularly an organic light-emitting diode, characterized by

-- a transparent bottom electrode (22) situated on a substrate (21);

-- a top electrode (26) composed of a metal that is inert to oxygen and moisture;

-- at least one organic function layer (23, 24) arranged between the bottom electrode (22) and the top electrode (26); and

-- a charge carrier injection layer (25) containing a complex metal salt of the composition (Me1) $(Me2)F_{m+n}$, whereby the following applies:

m and n are respectively a whole number corresponding to the valence of the metals Me1 and Me2 (the metal Me1 thereby has the valence m, the metal Me2 the valence n),

Me1 = Li, Na, K, Mg or Ca,

Me2 = Mg, Al, Ca, Zn, Ag, Sb, Ba, Sm or Yb,

with the prescription: Me1 $\neq$ Me2.

2. Component according to claim 1, characterized in that the top electrode (26) is composed of aluminum, silver, platinum or gold or of an alloy of two of these metals.

3. Component according to claim 1 or 2, characterized in that the charge carrier injection layer (25) is arranged between the top electrode (26) and the organic function layer (24).

4. Component according to one of the claims 1 through 3, characterized in that the charge carrier injection layer (25) comprises a thickness between 0.1 and 20 nm.

5. Component according to one or more of the claims 1 through 4, characterized in that the metal Me1 is lithium (Li) and/or the metal Me2 is magnesium (Mg), aluminum (Al), calcium (Ca), silver (Ag) or barium (Ba).

6. Component according to claim 5, characterized in that the complex metal salt is $LiAlF_4$, $LiAgF_2$ or $LiBaF_3$.

MARKED-UP VERSION

Abstract of the Disclosure

~~Organic Electroluminescent Component~~

The organic electroluminescent component in the ~~of the invention comprises the following constituents:~~

-- a transparent bottom electrode ~~(22)~~ situated on a substrate ~~(21)~~;

-- a top electrode ~~(26)~~ composed of a metal that is inert to oxygen and moisture;

-- at least one organic function layer ~~(23, 24)~~ arranged between the bottom electrode ~~(22)~~ and the top electrode ~~(26)~~; and

-- a charge carrier injection layer ~~(25)~~ containing a complex metal salt of the composition (Me1) (Me2)F_{m+n}, whereby the following applies:

m and n are respectively a whole number corresponding to the valence of the metals Me1 and Me2 (the metal Me1 thereby has the valence m, the metal Me2 the valence n),

Me1 ~~=~~ is selected from a group consisting of Li, Na, K, Mg ~~or~~ and Ca,

Me2 ~~=~~ is selected from a group consisting of Mg, Al, Ca, Zn, Ag, Sb, Ba, Sm ~~or~~ and Yb,

with the prescription: Me1 $\neq$ Me2.

~~Figure 2~~

TITLE

"ORGANIC ELECTROLUMINESCENT COMPONENT"

BACKGROUND OF THE INVENTION

The invention is directed to an organic electroluminescent component, particularly an organic light-emitting diode.

The visualization of data is constantly increasing in significance due to the great increase in the amount of information. The technology of flat picture screens ("flat panel displays") was developed therefor for employment in mobile and portable electronic devices. The market of flat panel displays is currently largely dominated by the technology of liquid crystal displays (LC displays). In addition to cost-beneficial manufacture, low electrical power consumption, low weight and slight space requirement, however, the technology of LC displays also exhibits serious disadvantages.

LC displays are not self-emitting and can therefore only be easily read or recognized given especially beneficial ambient light conditions. This makes a back-illumination device necessary in most instances, but this multiplies the thickness of the flat panel display. Moreover, the majority part of the electrical power consumption of the display is then needed for the illumination, and a higher voltage is required for the operation of the lamps or fluorescent tubes, which higher voltage is usually generated from batteries or accumulators with the assistance of "voltage-up converters". Other disadvantages are the highly limited observation angles of LC displays and the long switching times of individual pixels, which switching times typically lie at a few milliseconds and also are highly temperature-dependent. The delayed image build-up is considered extremely disturbing, for example, given utilization in means of conveyance or given video applications.

There are other flat panel display technologies in addition to LC displays, for example the technology of flat display panel cathode ray tubes, of vacuum-fluorescence displays and of inorganic thin-film electroluminescent displays. However, either these technologies have not yet achieved the required degree of technological maturity or -- due to high operating voltages or, respectively, high manufacturing costs -- they are only conditionally suited for utilization in portable electronic devices.

Displays on the basis of organic light-emitting diodes, which are called OLEDs, do not exhibit these disadvantages. The necessity of a back-illumination is eliminated due to the self-emissivity, as a result whereof the space requirement and the electrical power consumption are considerably reduced. The switching times lie at about one microsecond and are only slightly temperature-dependent, which enables employment for video applications. The reading angle amounts to nearly 180°, and polarization films that are required given LC displays are eliminated, so that a greater brightness of the display elements can be achieved. Further advantages are the employability of flexible and non-planar substrates as well as a simple and cost-beneficial manufacture.

The construction of organic light-emitting diodes typically ensues in the following way.

A transparent substrate, for example glass, is coated with a transparent electrode (bottom electrode, anode), composed, for example, of indium tin oxide (ITO). Dependent on the application, the transparent electrode is then structured with the assistance of a photolithographic process.

One or more organic layers composed of polymers, oligomers, low-molecular compounds or mixtures thereof are applied on the substrate with the structured electrode. Examples of polymers are polyaniline, poly(p-phenylene-

vinylene) and poly(2-methoxy-5-(2'-ethyl)-hexyloxy-p-phenylene-vinylene). Examples of low-molecular compounds that preferably transport positive charge carriers are N,N'-bis-(3-methylphenyl)-N,N'-bis-(phenyl)-benzidine (m-TPD), 4,4',4"-tris-(N-3-methylphenyl-N-phenyl-amino)-triphenylamine (m-MTDATA) and 4,4',4"-tris-(carbazole-9-yl)-triphenylamine (TCTA). Hydroxy-chinoline aluminum-III salt (Alq_3) that can be doped with suitable chromophores (chinacridone derivatives, aromatic hydrocarbons, etc.), for example, is employed as an emitter. As warranted, additional substances that influence the electro-optical and the long-term properties, such as copper phthalocyanine, can be present. The application of polymers usually ensues from the liquid phase with doctor blades or spin-coating; low-molecular and oligomeric compounds are usually deposited from the vapor phase by vapor deposition or "physical vapor deposition" (PVD). The overall layer thickness can amount to between 10 nm and 10 μm and it typically lies in the range between 50 and 200 nm.

A cooperating electrode (top electrode, cathode), which is usually composed of a metal, of a metal alloy or of a thin insulator layer and a thick metal layer, is applied onto the organic layer or layers. The manufacture of the cathode layer usually ensues with vapor phase deposition by means of thermal evaporation, electron beam evaporation or sputtering.

When metals are employed as cathode material, then these must have a low work function (typically < 3.7 eV) so that electrons can be efficiently injected into the organic semiconductor. Alkaline metals, alkaline earth metals or rare earth metals are usually employed for this purpose and the layer thickness lies between 0.2 nm and a few hundred nanometers but generally at a few 10 nanometers. Since, however, these non-precious metals tend toward corrosion under atmospheric conditions, it is necessary to additionally apply a layer of a more precious, inert metal

such as aluminum (Al), copper (Cu), silver (Ag) or gold (Au) onto the cathode layer that protects the non-precious metal layer against moisture and atmospheric oxygen.

For increasing the stability of the cathodes against a corrosion-caused hole formation, an alloy composed of an efficiently electron-injecting but corrosion-susceptible non-precious metal (work function < 3.7 eV) and a corrosion-resistant or precious metal, such as Al, Cu, Ag and Au, is often employed instead of an unalloyed non-precious metal. The proportion of the non-precious metal in the alloy can amount to between a few tenths of a percent and approximately 90%. The alloys are usually generated by simultaneous deposition of the metals from the vapor phase, for example by co-vapor deposition, simultaneous sputtering with a plurality of sources and sputtering upon employment of alloy targets. However, a layer of a precious metal or corrosion-resistant metal, such as Al, Cu, Ag or Au, is usually also additionally applied onto such cathodes as protection against corrosion.

Cathodes composed of precious metals, i.e. metals having a work function > 3.7 eV, are very inefficient electron injectors when they are utilized in direct contact with the organic semiconductor. When, however, a thin insulating intermediate layer (layer thickness generally between 0.2 and 5 nm) is arranged between the uppermost, electron-conducting organic layer and the metal electrode, then the efficiency of the light-emitting diodes rises substantially. Oxides such as aluminum oxide, alkaline and alkaline earth oxides and other oxides as well as alkaline and alkaline earth fluorides come into consideration as the insulating material for such an intermediate layer (in this respect, see Appl. Phys. Lett., Vol. 71 (1997), pages 2560 through 2562; United States Letters Patent 5,677,572; European Published Application 0 822 603). A metal electrode that is composed of a pure metal or of a metal alloy is then applied onto the thin, insulating intermediate layer. The insulating material can thereby also be applied together with the electrode

material by means of co-vapor deposition (Appl. Phys. Lett., Vol. 73 (1998), pages 1185 through 1187).

SUMMARY OF THE INVENTION

An object of the invention is to fashion an organic electroluminescent component, particularly an organic light-emitting diode, such that, on the one hand, a hermetic seal of the top electrode can be foregone and, on the other hand, the selection of materials employable at the cathode side is greater.

This is inventively achieved by a component that is characterized by or comprises

-- a transparent bottom electrode situated on a substrate;

-- a top electrode composed of a metal that is inert to oxygen and moisture;

-- at least one organic function layer arranged between the bottom electrode and the top electrode; and

-- a charge carrier injection layer containing a complex metal salt of the composition (Me1) (Me2)F_{m+n}, whereby the following applies:

m and n are respectively a whole number corresponding to the valence of the metals Me1 and Me2 (the metal Me1 thereby has the valence m, the metal Me2 the valence n),

Me1 is selected from a group consisting of Li, Na, K, Mg and Ca.

Me2 is selected from a group consisting of Mg, Al, Ca, Zn, Ag, Sb, Ba, Sm and Yb,

with the prescription: Me1 $\neq$ Me2.

The critical feature of the organic electroluminescent component of the invention is thus in a specific structure at the cathode side, namely in the combination of a top electrode that is indifferent with respect to environmental influences with a

charge carrier injection layer composed of a specific complex metal salt having the composition (Me1) $(Me2)F_{m+n}$, i.e. a double fluoride. As a result of this structure, a hermetic seal or, respectively, sealing of the top electrode can be omitted. As a result of the specific material for the charge carrier injection layer, not only is the offering for the materials employable at the cathode side broadened, this material also achieves an improvement of the emission properties, which are expressed in a clearly higher light yield, a reduced operating voltage and a longer service life during operation.

The charge carrier injection layer (composed of a specific complex metal salt) is preferably arranged as a thin insulating layer either between the top electrode and the organic function layer or between the uppermost function layer and the top electrode given the presence of a plurality of function layers. When an electron transport layer is also additionally located on the (uppermost) function layer given the component of the invention, then the charge carrier injection layer is arranged between this transport layer and the top electrode. In all of these instances, the thickness of the charge carrier injection layer preferably amounts to approximately 0.1 through 20 nm.

However, the charge carrier injection layer can also be quasi-integrated into the top electrode, into the (uppermost) organic function layer or into an electron transport layer that is potentially present, i.e. the complex metal salt is then a constituent part of one of these layers. The production of such layers can advantageously ensue by means of co-vapor deposition of the corresponding materials, for example by co-vapor deposition of the top electrode material and of the complex metal salt.

The complex metal salt exhibits the composition (Me1) (Me2)F_{m+n}, whereby m and n correspond to the valence of the respective metal. m = 1 (Li, Na, K) or m = 2 (Mg, Ca) is valid for Me1; n = 1 (Ag) or n = 2 (Mg, Ca, Zn, Ba) or n = 3 (Al, Sb, Sm, Yb) is valid for Me2. The metal Me1 is preferably lithium (Li); the metal Me2 is preferably magnesium (Mg), aluminum (Al), calcium (Ca), silver (Ag) or Barium (Ba).

Advantageously, one of the double fluorides $LiAgF_2$, $LiBaF_3$ and $LiAlF_4$ is employed as the complex metal salt. More such double fluorides are, for example, $NaAgF_2$, $KAgF_2$, $LiMgF_3$, $LiCaF_3$, $CaAgF_3$ and $MgBaF_4$. Complex salts of this type as well as methods for manufacturing them are known in and of themselves (in this respect, see the exemplary embodiments as well as, for example, "Gmelins Handbuch der Anorganischen Chemie", 8th Edition (1926), System Number 5 (fluorine), pages 58 through 72).

The top electrode, which generally comprises a thickness > 100 nm, is preferably composed of one of the following metals: aluminum (Al), silver (Ag), platinum (Pt) and gold (Au). The electrode material, however, can also be an alloy of two of these metals. Magnesium (Mg), calcium (Ca), zinc (Zn), antimony (Sb) and barium (Ba) come into consideration as other metals for the top electrode.

The bottom electrode is generally composed of indium tin oxide (ITO). Other possible materials for the bottom electrode are tin oxide and bismuth oxide. Glass generally serves as the substrate for the bottom electrode.

The component of the invention preferably comprises two organic function layers, namely an apertured conducting layer arranged at the bottom electrode that transports positive charge carriers and an emission layer situated thereon that is also referred to as the luminescence layer. Two or more apertured conducting layers can also be advantageously utilized instead of one apertured conducting layer.

The materials for these layers are known in and of themselves. In the present case, N,N'-bis-(3-methylphenyl)-N,N'-bis(phenyl)-benzidine (m-TPD), 4,4',4"-tris-(N-1-naphthyl-N-phenylamino)-triphenylamine (naphdata) or N,N'-bis-phenyl-N,N'-bis-α-naphthyl-benzidine (α-NPD) is preferably employed for the apertured conducting layer or layers. The material for the emission layer is preferably hydroxychinoline aluminum-III salt (Alq_3). Simultaneously, this material can also serve for the electron transport. For example, chinacridone can also be utilized for the emission layer, and one of the oxadiazole derivatives known for this purpose for a potentially present electron transport layer.

The invention offers the following, additional advantages, particularly in view of organic light-emitting diodes:

-- Facilitated Handling

Due to the stability of the material of the top electrode, work need not be carried out under an inert gas atmosphere in the manufacture and further-processing of OLEDs.

-- Performance

Compared to top electrodes of non-precious metals, the operating voltage is clearly lowered and the light yield and efficiency are considerably enhanced.

-- Improved Properties

Compared, for example, to LiF as the material for the intermediate layer, compounds such as $LiAlF_4$ have the advantage that they are less hygroscopic, which facilitates the handling and storage. The double fluorides are also easier to evaporate and are less basic than LiF, as a result whereof the compatibility with the organic function layers is increased.

The invention shall be explained in still greater detail on the basis of exemplary embodiments and Figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a diagrammatic view of a traditional OLED display;

Figure 2 is a diagrammatic view of an OLED display of the invention;

Figure 3 is a graph showing luminance/voltage characteristics;

Figure 4 is a graph showing efficiency/luminance characteristics;

Figure 5 is a graph showing a comparison of the luminance of various materials.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Example 1

Production of lithium aluminum fluoride $LiAlF_4$

Lithium aluminum hydride $LiAlH_4$ is carefully hydrolyzed with distilled water and conversion is subsequently undertaken with hydrofluoric acid (HF) being in excess. The complex metal salt $LiAlF_4$ that thereby precipitates out is extracted, repeatedly washed with water and ethanol and then dried.

Example 2

Production of lithium silver fluoride $LiAgF_2$

A solution of stoichiometric quantities of lithium hydroxide and silver acetate is glacial acetic acid is converted with hydrofluoric acid (HF) being in excess upon exclusion of light and the complex metal salt $LiAgF_2$ thereby precipitates out. The complex salt is extracted after the addition of the same volume of ethanol, is washed with ethanol and dried.

Example 3

Production of lithium barium fluoride $LiBa_3$

An aqueous solution of stoichiometric quantities of lithium hydroxide and barium hydroxide is converted with hydrofluoric acid (HF) being in excess. The complex metal salt $LiBaF_3$ precipitates out when chilled (cooling with ice) and it is extracted, repeatedly washed with ethanol and then dried.

The complex metal salt $LiCaF_3$ is produced in a corresponding way, whereby the reaction solution is constricted as warranted.

The complex metal salt $LiMgF_3$ can be produced in the same way and lithium methylate and magnesium methylate are then utilized as the initial substances.

Example 4

Manufacture of a traditional OLED display 10 with a Mg/Ag cathode (see Figure 1)

An ITO layer 12 having a thickness of approximately 100 nm is applied onto a glass substrate 11. This layer is then photolithographically structured in such a way that a stripe-shaped structure is produced. A layer 13 of m-TPD having a thickness of approximately 100 nm is first applied by thermal evaporation onto the coated substrate pre-treated in this way, followed by a layer 14 of Alq_3 having a thickness of approximately 65 nm.

A layer 15 of a magnesium-silver alloy (Mg:Ag mixing ratio 10:1) having a thickness of approximately 150 nm is applied onto the organic layer 14 by thermal evaporation with two simultaneously operated evaporator sources, and a layer 16 of pure silver having a thickness of approximately 150 nm is applied on the layer 15, likewise by thermal evaporation. The metal layers are thereby vapor-deposited through a mask with stripe-shaped openings, so that cathode stripes that lie

perpendicular to the ITO stripes are produced. Organic light-emitting diodes with an active area of 2 x 2 mm^2 respectively are produced in this way at the intersections of the ITO tracks with the metal tracks -- together with the organic layers lying therebetween. During operation, the ITO layer is positively contacted and the metal tracks are negatively contacted.

Example 5

Manufacture of an OLED display 20 of the invention (see Figure 2)

An ITO layer 22 having a thickness of approximately 100 nm is applied onto a glass substrate 21. This layer is then photolithographically structured in such a way that a stripe-shaped structure is produced. A layer 23 of m-TPD having a thickness of approximately 100 nm is first applied by thermal evaporation onto the coated substrate pre-treated in this way, followed by a layer 24 of Alq_3 having a thickness of approximately 65 nm.

A layer 25 of $LiAlF_4$ having a thickness of approximately 1 nm is applied by thermal evaporation onto the layer 24, and a layer 26 of aluminum -- serving as a top electrode -- having a thickness of approximately 150 nm is applied onto said layer 25, likewise by thermal evaporation. The two layers are thereby vapor-deposited through a mask with stripe-shaped openings, corresponding to Example 4, so that organic light-emitting diodes are produced. During operation, the ITO layer is positively contacted and the top electrode is negatively contacted.

The results of measurements at the OLEDs corresponding to Examples 4 and 5 are compiled in Table 1. The threshold voltage (of the electroluminescence), the voltage and the efficiency (respectively given a luminance of 1500 cd/m^2), the maximum luminance and the luminance given a current density of 50 mA/cm^2) are thereby recited as characteristic data.

Table 1

Exampl e	Threshold voltage [V]	Voltage [V] at 1500 cd/m^3	Efficiency [lm/W] at 1500 cd/m^2	Maximum luminance [cd/m^2]	Luminance [cd/m^2] at 50 mA/cm^2
4	2.08	14.48	0.677	15957	1544
5	1.87	14.12	0.720	18801	1605

It can be seen that the threshold voltage and the operating voltage of the display of the invention (Example 5) lie below the corresponding values given the traditional display (Example 4), even though the thickness of the $LiAlF_4$ was not optimized. The values for the efficiency and the luminances that are achieved given the display of the invention lie above the corresponding values of the traditional display.

Figure 3 shows the luminance/voltage characteristics of the displays according to Examples 4 and 5. The increased luminance of the display of the invention can be clearly seem from this illustration.

The following can be stated overall:

-- The display of the invention (Example 5) employs a cathode of aluminum with which efficiencies are normally achieved that lie approximately 40 to 50% below the corresponding values given Mg/Ag cathodes (Example 4). Aluminum, on the other hand, is more stable than magnesium vis a vis environmental influences such as atmospheric oxygen and moisture.

-- Due to the introduction of a thin $LiAlF_4$ between the organic function layers and the Al cathode, however, the efficiency of OLEDs having an Al cathode can be increased, namely even above the corresponding values of OLEDs with Mg/Ag cathode. In this way, high-efficiency OLEDs with stable cathode can be constructed.

Example 6

Manufacture of an OLED display with a Mg/Ag cathode

An ITO layer having a thickness of approximately 100 nm is applied onto a glass substrate. This layer is then photolithographically structured in such a way that a stripe-shaped structure is produced. A layer of naphdata having a thickness of approximately 55 nm is first applied by thermal evaporation onto the coated substrate pre-treated in this way, followed by a layer of α-NPD having a thickness of approximately 5 nm, and, finally, a layer of Alq_3 having a thickness of approximately 65 nm.

A layer of a magnesium-silver alloy (Mg:Ag mixing ratio 10:1) having a thickness of approximately 150 nm is applied onto the uppermost organic layer (of Alq_3) by thermal evaporation with two simultaneously operated evaporator sources, and a layer of pure silver having a thickness of approximately 150 nm is applied on the uppermost organic layer, likewise by thermal evaporation. The metal layers are thereby vapor-deposited through a mask with stripe-shaped openings, so that cathode stripes that lie perpendicular to the ITO stripes are produced. Organic light-emitting diodes with an active area of 2 x 2 mm^2 respectively are produced in this way at the intersections of the ITO tracks with the metal tracks -- together with the organic layers lying therebetween. During operation, the ITO layer is positively contacted and the metal tracks are negatively contacted.

Example 7

Manufacture of an OLED display with an Al cathode

Corresponding to Example 6, a display having three organic function layers is constructed. A layer of aluminum having a thickness of 150 nm is then applied in

a corresponding way by thermal evaporation onto the uppermost organic layer (of Alq_3).

Example 8

Manufacture of an OLED display with an Al cathode and an LiF intermediate layer

A display with three organic function layers is constructed corresponding to Example 6. A layer of LiF having a thickness of approximately 0.5 nm is then applied onto the uppermost organic layer (of Alq_3) by thermal evaporation, and a layer of aluminum having a thickness of approximately 150 nm is applied on the uppermost organic layer. The two layers are thereby vapor-deposited through a mask having stripe-shaped openings in conformity with Example 6, so that organic light-emitting diodes are produced. During operation, the ITO layer is positively contacted and the Al cathode is negatively contacted.

Example 9

Manufacture of an OLED display with an Al cathode and a $LiAlF_4$ charge carrier injection layer

A display with three organic function layers is constructed corresponding to Example 8. A layer of $LiAlF_4$ having a thickness of approximately 0.5 nm is then applied by thermal evaporation onto the uppermost organic layer (of Alq_3), and a layer of aluminum -- serving as top electrode -- having a thickness of approximately 150 nm is applied onto the $LiAlF_4$ layer, likewise by thermal evaporation. The structuring and the contacting ensue in conformity with Example 8.

Example 10

Manufacture of an OLED display with an Al cathode and a $LiAgF_2$ charge carrier injection layer

A display with three organic function layers is constructed corresponding to Example 6. A layer of $LiAgF_2$ having a thickness of approximately 0.5 nm is then applied by thermal evaporation onto the uppermost organic layer (of Alq_3), and a layer of aluminum -- serving as a top electrode -- having a thickness of approximately 150 nm is applied onto said $LiAlF_4$ layer, likewise by thermal evaporation. The structuring and the contacting ensue in conformity with Example 8.

Example 11

Manufacture of an OLED display with an Al cathode and a $LiBaF_3$ charge carrier injection layer

A display with three organic function layers is constructed corresponding to Example 6. A layer of $LiBaF_3$ having a thickness of approximately 0.5 nm is then applied by thermal evaporation onto the uppermost organic layer (of Alq_3), and a layer of aluminum -- serving as a top electrode -- having a thickness of approximately 150 nm is applied onto the $LiAlF_4$ layer, likewise by thermal evaporation. The structuring and the contacting ensue in conformity with Example 8.

The results of measurements at the OLEDs corresponding to Examples 6 through 11 are compiled in Table 2. The threshold voltage (of the electroluminescence), the voltage and the efficiency (respectively given a luminance of 1500 cd/m^2), the maximum luminance and the luminance given a current density of 50 mA/cm^2) are thereby recited as characteristic data.

Table 2

Example	Threshold voltage [V]	Voltage [V] at 1500 cd/m^3	Efficiency [lm/W] at 1500 cd/m^2	Luminance [cd/m^2] at 50 mA/cm^2
6	3.19	9.96	1.08	1722
7	7.15	16.52	0.48	1275
8	3.17	9.47	1.19	1809
9	4.23	11.97	0.88	1684
10	3.49	10.86	1.00	1745
11	2.56	9.58	1.26	1948

It can be seen that the threshold voltages and the operating voltages of the displays of the invention (Examples 9 through 11) that comprise an Al cathode and a charge carrier injection layer composed of a complex metal salt are comparable to the values that are obtained given displays with a Mg/Ag cathode or, respectively, with an Al cathode and a LiF intermediate layer (Examples 6 and 8) and lie clearly below the corresponding values given a display with a pure Al cathode (Example 7). The displays of the invention are also comparable to the Mg/Ag and Al-LiF displays in view of the efficiency and the luminance, whereby a display with a $LiBaF_3$ charge carrier injection layer (Example 11), in particular, exhibits high values.

Figure 4 shows the efficiency/luminance characteristics of the Examples 6 through 11. In particular, the superior position of an Al-$LiBaF_3$ of the invention can be clearly seen from this illustration.

It can be stated overall that the efficiency of LEDs with an Al cathode can be boosted above the corresponding values of OLEDs with a Mg/Ag cathode by introducing thin layers of a complex metal salt such as $LiAlF_4$, $LiAgF_2$ and $LiBaF_3$ between the organic function layers and the cathode. High-efficiency OLEDS with stable contact can be constructed in this way.

The values for the luminance (given a current density of 50 mA/cm^2) of the materials according to Examples 6 through 11 are compared to one another in Figure 5. The good results that can be achieved with the displays of the invention also can be derived therefrom.

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ORGANIC ELECTROLUMINESCENT COMPONENT

The invention is directed to an organic electroluminescent component, particularly an organic light-emitting diode.

The visualization of data is constantly increasing in significance due to the great increase in the amount of information. The technology of flat picture screens ("flat panel displays") was developed therefor for employment in mobile and portable electronic devices. The market of flat panel displays is currently largely dominated by the technology of liquid crystal displays (LC displays). In addition to cost-beneficial manufacture, low electrical power consumption, low weight and slight space requirement, however, the technology of LC displays also exhibits serious disadvantages.

LC displays are not self-emitting and can therefore only be easily read or recognized given especially beneficial ambient light conditions. This makes a back-illumination device necessary in most instances, but this multiplies the thickness of the flat panel display. Moreover, the majority part of the electrical power consumption is then needed for the illumination, and a higher voltage is required for the operation of the lamps or fluorescent tubes; this is usually generated from batteries or accumulators with the assistance of "voltage-up converters". Other disadvantages are the highly limited observation angles of LC displays and the long switching times of individual pixels, these typically lying at a few milliseconds and also being highly temperature-dependent. The delayed image build-up is considered extremely disturbing, for example, given utilization in means of conveyance or given video applications.

There are other flat panel display technologies in addition to LC displays, for example the technology of flat display panel cathode ray tubes, of vacuum-fluorescence displays and of inorganic thin-film electroluminescent displays. These technologies, however, have either not yet achieved the required degree of technological maturity or -- due to high operating voltages or, respectively, high

manufacturing costs -- they are only conditionally suited for utilization in portable electronic devices.

Displays on the basis of organic light-emitting diodes (=OLEDs) do not exhibit said disadvantages. The necessity of a back-illumination is eliminated due to the self-emissivity, as a result whereof the space requirement and the electrical power consumption are considerably reduced. The switching times lie at about one microsecond and are only slightly temperature-dependent, which enables employment for video applications. The reading angle amounts to nearly 180°, and polarization films as required given LC displays are eliminated, so that a greater brightness of the display elements can be achieved. Further advantages are the employability of flexible and non-planar substrates as well as a simple and cost-beneficial manufacture.

The construction of organic light-emitting diodes typically ensues in the following way.

A transparent substrate, for example glass, is coated with a transparent electrode (bottom electrode, anode), composed, for example, of indium tin oxide (ITO). Dependent on the application, the transparent electrode is then structured with the assistance of a photolithographic process.

One or more organic layers composed of polymers, oligomers, low-molecular compounds or mixtures thereof are applied on the substrate with the structured electrode. Examples of polymers are polyaniline, poly(p-phenylene-vinylene) and poly(2-methoxy-5-(2'-ethyl)-hexyloxy-p-phenylene-vinylene). Examples of low-molecular compounds that preferably transport positive charge carriers are N,N'-bis-(3-methylphenyl)-N,N'-bis-(phenyl)-benzidine (m-TPD), 4,4',4"-tris-(N-3-methylphenyl-N-phenyl-amino)-triphenylamine (m-MTDATA) and 4,4',4"-tris-(carbazole-9-yl)-triphenylamine (TCTA). Hydroxy-chinoline aluminum-III salt (Alq_3) that can be doped with suitable chromophores (chinacridone derivatives, aromatic hydrocarbons, etc.), for example, is employed as emitter. As warranted, additional substances that influence the electro-optical and the long-term properties, such as copper phthalocyanine, can be present. The application of polymers usually ensues from the liquid phase with doctor blades or spin-coating; low-molecular and

oligomeric compounds are usually deposited from the vapor phase by vapor deposition or "physical vapor deposition" (PVD). The overall layer thickness can amount to between 10 nm and 10 μm; it typically lies in the range between 50 and 200 nm.

A cooperating electrode (top electrode, cathode), which is usually composed of a metal, of a metal alloy or of a thin insulator layer and a thick metal layer, is applied onto the organic layer or layers. The manufacture of the cathode layer usually ensues with vapor phase deposition by means of thermal evaporation, electron beam evaporation or sputtering.

When metals are employed as cathode material, then these must have a low work function (typically < 3.7 eV) so that electrons can be efficiently injected into the organic semiconductor. Alkaline metals, alkaline earth metals or rare earth metals are usually employed for this purpose; the layer thickness lies between 0.2 nm and a few hundred nanometers but generally at a few 10 nanometers. Since, however, these non-precious metals tend toward corrosion under atmospheric conditions, it is necessary to additionally apply a layer of a more precious, inert metal such as aluminum (Al), copper (Cu), silver (Ag) or gold (Au) onto the cathode layer that protects the non-precious metal layer against moisture and atmospheric oxygen.

For increasing the stability of the cathodes against a corrosion-caused hole formation, an alloy composed of an efficiently electron-injecting but corrosion-susceptible non-precious metal (work function < 3.7 eV) and a corrosion-resistant precious metal, such as Al, Cu, Ag and Au, is often employed instead of an unalloyed non-precious metal. The proportion of the non-precious metal in the alloy can amount to between a few tenths of a percent and approximately 90%. The alloys are usually generated by simultaneous deposition of the metals from the vapor phase, for example by co-vapor deposition, simultaneous sputtering with a plurality of sources and sputtering upon employment of alloy targets. However, a layer of precious metal, such as Al, Cu, Ag or Au, is usually also additionally applied onto such cathodes as protection against corrosion.

Cathodes composed of precious metals, i.e. metals having a work function > 3.7 eV, are very inefficient electron injectors when they are utilized in direct contact with the organic semiconductor. When, however, a thin insulating intermediate layer (layer thickness generally between 0.2 and 5 nm) is arranged between the uppermost, electron-conducting organic layer and the metal electrode, then the efficiency of the light-emitting diodes rises substantially. Oxides such as aluminum oxide, alkaline and alkaline earth oxides and other oxides as well as alkaline and alkaline earth fluorides come into consideration as insulating material for such an intermediate layer (in this respect, see Appl. Phys. Lett., Vol. 71 (1997), pages 2560 through 2562; United States Letters Patent 5,677,572; European Published Application 0 822 603). A metal electrode that is composed of a pure metal or of a metal alloy is then applied onto the thin, insulating intermediate layer. The insulating material can thereby also be applied together with the electrode material by means of co-vapor deposition (Appl. Phys. Lett., Vol. 73 (1998), pages 1185 through 1187).

An object of the invention is to fashion an organic electroluminescent component, particularly an organic light-emitting diode, such that, on the one hand, a hermetic seal of the top electrode can be foregone and, on the other hand, the selection of materials employable at the cathode side is greater.

This is inventively achieved by a component that is characterized by

-- a transparent bottom electrode situated on a substrate;

-- a top electrode composed of a metal that is inert to oxygen and moisture;

-- at least one organic function layer arranged between the bottom electrode and the top electrode; and

-- a charge carrier injection layer containing a complex metal salt of the composition (Me1) (Me2)F_{m+n}, whereby the following applies:

m and n are respectively a whole number corresponding to the valence of the metals Me1 and Me2 (the metal Me1 thereby has the valence m, the metal Me2 the valence n),

Me1 = Li, Na, K, Mg or Ca,

Me2 = Mg, Al, Ca, Zn, Ag, Sb, Ba, Sm or Yb,

with the prescription: Me1 ≠ Me2.

The critical feature of the organic electroluminescent component of the invention is thus comprised in a specific structure at the cathode side, namely in the combination of a top electrode that is indifferent with respect to environmental influences with a charge carrier injection layer composed of a specific complex metal salt having the composition (Me1) (Me2)F_{m+n}, i.e. a double fluoride. As a result of this structure, a hermetic seal or, respectively, sealing of the top electrode can be omitted. As a result of the specific material for the charge carrier injection layer, not only is the offering for the materials employable at the cathode side broadened, this material also achieves an improvement of the emission properties, expressed in a clearly higher light yield, a reduced operating voltage and a longer service life during operation.

The charge carrier injection layer (composed of a specific complex metal salt) is preferably arranged as a thin insulating layer between the top electrode and the organic function layer, between the uppermost function layer and the top electrode given the presence of a plurality of function layers. When an electron transport layer is also additionally located on the (uppermost) function layer given the component of the invention, then the charge carrier injection layer is arranged between this layer and the top electrode. In all of these instances, the thickness of the charge carrier injection layer preferably amounts to approximately 0.1 through 20 nm.

However, the charge carrier injection layer can also be quasi-integrated into the top electrode, into the (uppermost) organic function layer or into an electron transport layer that is potentially present, i.e. the complex metal salt is then a constituent part of one of said layers. The production of such layers can advantageously ensue by means of co-vapor deposition of the corresponding materials, for example by co-vapor deposition of the top electrode material and of the complex metal salt.

The complex metal salt exhibits the composition (Me1) $(Me2)F_{m+n}$, whereby m and n correspond to the valence of the respective metal. m = 1 (Li, Na, K) or m = 2 (Mg, Ca) is valid for Me1; n = 1 (Ag) or n = 2 (Mg, Ca, Zn, Ba) or n = 3 (Al, Sb, Sm, Yb) is valid for Me2. The metal Me1 is preferably lithium (Li); the metal Me2 is preferably magnesium (Mg), aluminum (Al), calcium (Ca), silver (Ag) or Barium (Ba).

Advantageously, one of the double fluorides $LiAgF_2$, $LiBaF_3$ and $LiAlF_4$ is employed as complex metal salt. More such double fluorides are, for example, $NaAgF_2$, $KAgF_2$, $LiMgF_3$, $LiCaF_3$, $CaAgF_3$ and $MgBaF_4$. Complex salts of this type as well as methods for manufacturing them are known in and of themselves (in this respect, see the exemplary embodiments as well as, for example, "Gmelins Handbuch der Anorganischen Chemie", 8th Edition (1926), System Number 5 (fluorine), pages 58 through 72).

The top electrode, which generally comprises a thickness > 100 nm, is preferably composed of one of the following metals: aluminum (Al), silver (Ag), platinum (Pt) and gold (Au). The electrode material, however, can also be an alloy of two of these metals. Magnesium (Mg), calcium (Ca), zinc (Zn), antimony (Sb) and barium (Ba) come into consideration as further metals for the top electrode.

The bottom electrode is generally composed of indium tin oxide (ITO). Further possible materials for the bottom electrode are tin oxide and bismuth oxide. Glass generally serves as substrate for the bottom electrode.

The component of the invention preferably comprises two organic function layers, namely an apertured conducting layer arranged at the bottom electrode that transports positive charge carriers and an emission layer situated thereon that is also referred to as luminescence layer. Two or more apertured conducting layers can also be advantageously utilized instead of one apertured conducting layer.

The materials for said layers are known in and of themselves. In the present case, N,N'-bis-(3-methylphenyl)-N,N'-bis(phenyl)-benzidine (m-TPD), 4,4',4"-tris-(N-1-naphthyl-N-phenylamino)-triphenylamine (naphdata) or N,N'-bis-phenyl-N,N'-bis-α-naphthyl-benzidine (α-NPD) is preferably employed for the

apertured conducting layer or layers. The material for the emission layer is preferably hydroxychinoline aluminum-III salt (Alq_3). Simultaneously, this material can also serve for the electron transport. For example, chinacridone can also be utilized for the emission layer, one of the oxadiazole derivatives known for this purpose for a potentially present electron transport layer.

The invention offers the following, further advantages, particularly in view of organic light-emitting diodes:

-- Facilitated Handling

Due to the stability of the material of the top electrode, work need not be carried out under an inert gas atmosphere in the manufacture and further-processing of OLEDs.

-- Performance

Compared to top electrodes of non-precious metals, the operating voltage is clearly lowered and the light yield and efficiency are considerably enhanced.

-- Improved Properties

Compared, for example, to LiF as material for the intermediate layer, compounds such as $LiAlF_4$ have the advantage that they are less hygroscopic, which facilitates the handling and storage. The double fluorides are also easier to evaporate and are less basic (than LiF), as a result whereof the compatibility with the organic function layers is increased.

The invention shall be explained in still greater detail on the basis of exemplary embodiments and Figures.

Shown are:

Figure 1 a traditional OLED display;

Figure 2 an OLED display of the invention;

Figure 3 luminance/voltage characteristics;

Figure 4 efficiency/luminance characteristics;

Figure 5 a comparison of the luminance of various materials.

Example 1

Production of lithium aluminum fluoride $LiAlF_4$

Lithium aluminum hydride $LiAlH_4$ is carefully hydrolyzed with distilled water; conversion is subsequently undertaken with hydrofluoric acid (HF) in excess. The complex metal salt $LiAlF_4$ that thereby precipitates out is extracted, repeatedly washed with water and ethanol and then dried.

Example 2

Production of lithium silver fluoride $LiAgF_2$

A solution of stoichiometric quantities of lithium hydroxide and silver acetate is glacial acetic acid is converted with hydrofluoric acid (HF) in excess upon exclusion of light; the complex metal salt $LiAgF_2$ thereby precipitates out. The complex salt is extracted after the addition of the same volume of ethanol, is washed with ethanol and dried.

Example 3

Production of lithium barium fluoride $LiBa_3$

An aqueous solution of stoichiometric quantities of lithium hydroxide and barium hydroxide is converted with hydrofluoric acid (HF) in excess. The complex metal salt $LiBaF_3$ precipitates out when chilled (cooling with ice); it is extracted, repeatedly washed with ethanol and then dried.

The complex metal salt $LiCaF_3$ is produced in a corresponding way, whereby the reaction solution is constricted as warranted.

The complex metal salt $LiMgF_3$ can be produced in the same way; lithium methylate and magnesium methylate are then utilized as initial substances.

Example 4

Manufacture of a traditional OLED display (10) with a Mg/Ag cathode (see Figure 1)

An ITO layer (12) having a thickness of approximately 100 nm is applied onto a glass substrate (11). This layer is then photolithographically structured in such a way that a stripe-shaped structure arises. A layer of m-TPD (13) having a thickness of approximately 100 nm is first applied by thermal evaporation onto the coated substrate pre-treated in this way, followed by a layer (14) of Alq_3 having a thickness of approximately 65 nm.

A layer (15) of a magnesium-silver alloy (Mg:Ag mixing ratio 10:1) having a thickness of approximately 150 nm is applied onto the organic layer (14) by thermal evaporation with two simultaneously operated evaporator sources, and a layer (16) of pure silver having a thickness of approximately 150 nm is applied on said layer (15), likewise by thermal evaporation. The metal layers are thereby vapor-deposited through a mask with stripe-shaped openings, so that cathode stripes that lie perpendicular to the ITO stripes arise. Organic light-emitting diodes with an active area of 2 x 2 mm^2 respectively arise in this way at the intersections of the ITO tracks with the metal tracks -- together with the organic layers lying therebetween. During operation, the ITO layer is positively contacted; the metal tracks are negatively contacted.

<u>Example 5</u>

Manufacture of an OLED display (20) of the invention (see Figure 2)

An ITO layer (22) having a thickness of approximately 100 nm is applied onto a glass substrate (21). This layer is then photolithographically structured in such a way that a stripe-shaped structure arises. A layer of m-TPD (23) having a thickness of approximately 100 nm is first applied by thermal evaporation onto the coated substrate pre-treated in this way, followed by a layer (24) of Alq_3 having a thickness of approximately 65 nm.

A layer (25) of $LiAlF_4$ having a thickness of approximately 1 nm is applied by thermal evaporation onto the organic layer (24), and a layer (26) of aluminum -- serving as top electrode -- having a thickness of approximately 150 nm is applied onto said layer (25), likewise by thermal evaporation. The two layers are

thereby vapor-deposited through a mask with stripe-shaped openings, corresponding to Example 4, so that organic light-emitting diodes arise. During operation, the ITO layer is positively contacted, the top electrode negatively.

The results of measurements at the OLEDs corresponding to Examples 4 and 5 are compiled in Table 1. The threshold voltage (of the electroluminescence), the voltage and the efficiency (respectively given a luminance of 1500 cd/m^2), the maximum luminance and the luminance given a current density of 50 mA/cm^2) are thereby recited as characteristic data.

Table 1

Example	Threshold voltage [V]	Voltage [V] at 1500 cd/m^3	Efficiency [lm/W] at 1500 cd/m^2	Maximum luminance [cd/m^2]	Luminance [cd/m^2] at 50 mA/cm^2
4	2.08	14.48	0.677	15957	1544
5	1.87	14.12	0.720	18801	1605

It can be seen that the threshold voltage and the operating voltage of the display of the invention (Example 5) lie below the corresponding values given the traditional display (Example 4), even though the thickness of the $LiAlF_4$ was not optimized. The values for the efficiency and the luminances that are achieved given the display of the invention lie above the corresponding values of the traditional display.

Figure 3 shows the luminance/voltage characteristics of the displays according to Examples 4 and 5. The increased luminance of the display of the invention can be clearly seem from this illustration.

The following can be stated overall:

-- The display of the invention (Example 5) employs a cathode of aluminum with which efficiencies are normally achieved that lie approximately 40 to 50% below the corresponding values given Mg/Ag cathodes (Example 4). Aluminum, on the other hand, is more stable than magnesium vis a vis environmental influences such as atmospheric oxygen and moisture.

-- Due to the introduction of a thin $LiAlF_4$ between the organic function layers and the Al cathode, however, the efficiency of OLEDs having an Al cathode can be increased, namely even above the corresponding values of OLEDs with Mg/Ag cathode. In this way, high-efficiency OLEDs with stable cathode can be constructed.

Example 6

Manufacture of an OLED display with a Mg/Ag cathode

An ITO layer having a thickness of approximately 100 nm is applied onto a glass substrate. This layer is then photolithographically structured in such a way that a stripe-shaped structure arises. A layer of naphdata having a thickness of approximately 55 nm is first applied by thermal evaporation onto the coated substrate pre-treated in this way, followed by a layer of α-NPD having a thickness of approximately 5 nm, and, finally, a layer of Alq_3 having a thickness of approximately 65 nm.

A layer of a magnesium-silver alloy (Mg:Ag mixing ratio 10:1) having a thickness of approximately 150 nm is applied onto the uppermost organic layer (of Alq_3) by thermal evaporation with two simultaneously operated evaporator sources, and a layer of pure silver having a thickness of approximately 150 nm is applied on said uppermost organic layer, likewise by thermal evaporation. The metal layers are thereby vapor-deposited through a mask with stripe-shaped openings, so that cathode stripes that lie perpendicular to the ITO stripes arise. Organic light-emitting diodes with an active area of 2 x 2 mm^2 respectively arise in this way at the intersections of the ITO tracks with the metal tracks -- together with the organic layers lying therebetween. During operation, the ITO layer is positively contacted; the metal tracks are negatively contacted.

Example 7

Manufacture of an OLED display with an Al cathode

Corresponding to Example 6, a display having three organic function layers is constructed. A layer of aluminum having a thickness of 150 nm is then applied in a corresponding way by thermal evaporation onto the uppermost organic layer (of Alq_3).

Example 8

Manufacture of an OLED display with an Al cathode and an LiF intermediate layer

A display with three organic function layers is constructed corresponding to Example 6. A layer of LiF having a thickness of approximately 0.5 nm is then applied onto the uppermost organic layer (of Alq_3) by thermal evaporation, and a layer of aluminum having a thickness of approximately 150 nm is applied on said uppermost organic layer. The two layers are thereby vapor-deposited through a mask having stripe-shaped openings in conformity with Example 6, so that organic light-emitting diodes arise. During operation, the ITO layer is positively contacted, the Al cathode negatively.

Example 9

Manufacture of an OLED display with an Al cathode and a $LiAlF_4$ charge carrier injection layer

A display with three organic function layers is constructed corresponding to Example 8. A layer of $LiAlF_4$ having a thickness of approximately 0.5 nm is then applied by thermal evaporation onto the uppermost organic layer (of Alq_3), and a layer of aluminum -- serving as top electrode -- having a thickness of approximately 150 nm is applied onto said $LiAlF_4$ layer, likewise by thermal evaporation. The structuring and the contacting ensue in conformity with Example 8.

Example 10

Manufacture of an OLED display with an Al cathode and a $LiAgF_2$ charge carrier injection layer

A display with three organic function layers is constructed corresponding to Example 6. A layer of $LiAgF_2$ having a thickness of approximately 0.5 nm is then applied by thermal evaporation onto the uppermost organic layer (of Alq_3), and a layer of aluminum -- serving as top electrode -- having a thickness of approximately 150 nm is applied onto said $LiAlF_4$ layer, likewise by thermal evaporation. The structuring and the contacting ensue in conformity with Example 8.

Example 11

Manufacture of an OLED display with an Al cathode and a $LiBaF_3$ charge carrier injection layer

A display with three organic function layers is constructed corresponding to Example 6. A layer of $LiBaF_3$ having a thickness of approximately 0.5 nm is then applied by thermal evaporation onto the uppermost organic layer (of Alq_3), and a layer of aluminum -- serving as top electrode -- having a thickness of approximately 150 nm is applied onto said $LiAlF_4$ layer, likewise by thermal evaporation. The structuring and the contacting ensue in conformity with Example 8.

The results of measurements at the OLEDs corresponding to Examples 6 through 11 are compiled in Table 2. The threshold voltage (of the electroluminescence), the voltage and the efficiency (respectively given a luminance of 1500 cd/m^2), the maximum luminance and the luminance given a current density of 50 mA/cm^2) are thereby recited as characteristic data.

Table 2

Example	Threshold voltage [V]	Voltage [V] at 1500 cd/m^3	Efficiency [lm/W] at 1500 cd/m^2	Luminance [cd/m^2] at 50 mA/cm^2
6	3.19	9.96	1.08	1722
7	7.15	16.52	0.48	1275
8	3.17	9.47	1.19	1809
9	4.23	11.97	0.88	1684
10	3.49	10.86	1.00	1745
11	2.56	9.58	1.26	1948

It can be seen that the threshold voltages and the operating voltages of the displays of the invention (Examples 9 through 11) that comprise an Al cathode and a charge carrier injection layer composed of a complex metal salt are comparable to the values that are obtained given displays with a Mg/Ag cathode or, respectively, with an Al cathode and a LiF intermediate layer (Examples 6 and 8) and lie clearly below the corresponding values given a display with a pure Al cathode (Example 7). The displays of the invention are also comparable to the Mg/Ag and Al-LiF displays in view of the efficiency and the luminance, whereby a display with a $LiBaF_3$ charge carrier injection layer (Example 11), in particular, exhibits high values.

Figure 4 shows the efficiency/luminance characteristics of the Examples 6 through 11. In particular, the superior position of an Al-$LiBaF_3$ of the invention can be clearly seen from this illustration.

It can be stated overall that the efficiency of LEDs with an Al cathode can be boosted above the corresponding values of OLEDs with a Mg/Ag cathode by introducing thin layers of a complex metal salt such as $LiAlF_4$, $LiAgF_2$ and $LiBaF_3$ between the organic function layers and the cathode. High-efficiency OLEDS with stable contact can be constructed in this way.

The values for the luminance (given a current density of 50 mA/cm^2) of the materials according to Examples 6 through 11 are compared to one another in Figure 5. The good results that can be achieved with the displays of the invention also derive therefrom.

Patent Claims

1. Organic electroluminescent component, particularly an organic light-emitting diode, characterized by

-- a transparent bottom electrode (22) situated on a substrate (21);

-- a top electrode (26) composed of a metal that is inert to oxygen and moisture;

-- at least one organic function layer (23, 24) arranged between the bottom electrode (22) and the top electrode (26); and

-- a charge carrier injection layer (25) containing a complex metal salt of the composition (Me1) (Me2)F_{m+n}, whereby the following applies:
m and n are respectively a whole number corresponding to the valence of the metals Me1 and Me2 (the metal Me1 thereby has the valence m, the metal Me2 the valence n),
Me1 = Li, Na, K, Mg or Ca,
Me2 = Mg, Al, Ca, Zn, Ag, Sb, Ba, Sm or Yb,
with the prescription: Me1 $\neq$ Me2.

2. Component according to claim 1, characterized in that the top electrode (26) is composed of aluminum, silver, platinum or gold or of an alloy of two of these metals.

3. Component according to claim 1 or 2, characterized in that the charge carrier injection layer (25) is arranged between the top electrode (26) and the organic function layer (24).

4. Component according to one of the claims 1 through 3, characterized in that the charge carrier injection layer (25) comprises a thickness between 0.1 and 20 nm.

5. Component according to one or more of the claims 1 through 4, characterized in that the metal Me1 is lithium (Li) and/or the metal Me2 is magnesium (Mg), aluminum (Al), calcium (Ca), silver (Ag) or barium (Ba).

6. Component according to claim 5, characterized in that the complex metal salt is $LiAlF_4$, $LiAgF_2$ or $LiBaF_3$.

7. Component according to one or more of the claims 1 through 6, characterized in that two organic function layers (23, 24) are arranged between the bottom electrode (22) and the top electrode (26), whereby an apertured conducting layer (23) is located on the bottom electrode (22) and an emission layer (24) is located on said conducting layer (23).

8. Component according to claim 7, characterized in that the apertured conducting layer (23) contains N,N'-bis-(3-methylphenyl)-N,N'-bis(phenyl)-benzidine, 4,4',4"-tris-(N-1-naphthyl-N-phenylamino)-triphenylamine or N,N'-bis-phenyl-N,N'-bis-α-naphthyl-benzidine and/or the emission layer (24) hydroxychinoline aluminum-III salt.

9. Component according to one or more of the claims 1 through 8, characterized in that the bottom electrode (22) is composed of indium tin oxide.

10. Component according to one or more of the claims 1 through 9, characterized in that a electron transport layer is arranged on the at least one organic function layer (23, 24).

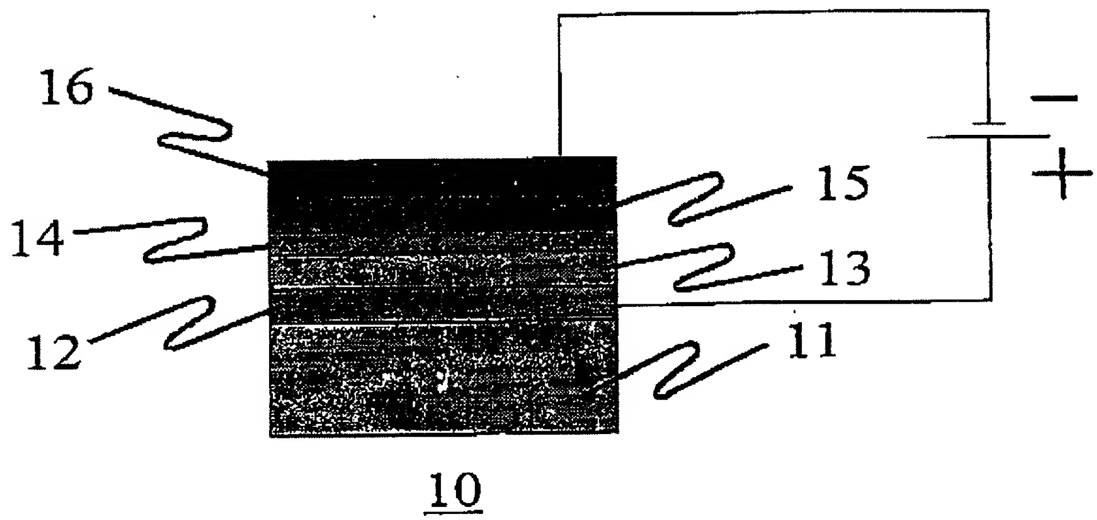

FIG 1

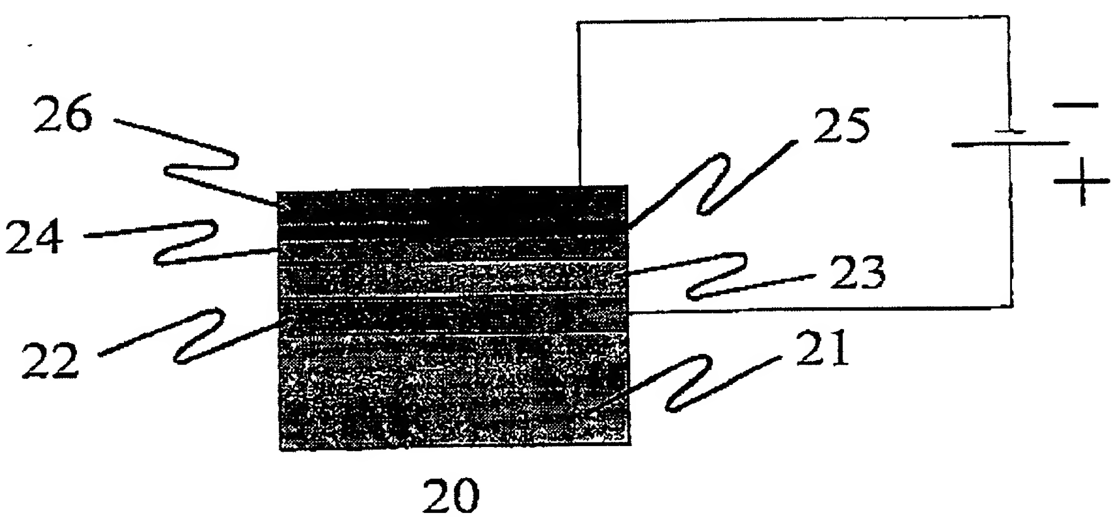

FIG 2

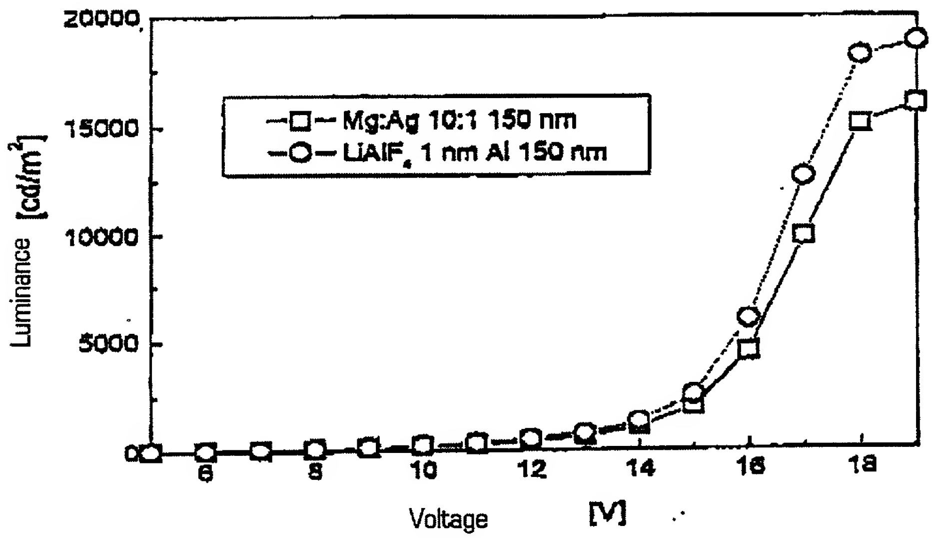
20000
15000
10000
5000
0
6
8
10
12
14
16
18
Luminance [cd/m²]
Voltage [V]
Mg:Ag 10:1 150 nm
LiAlF₄ 1 nm Al 150 nm

FIG 3

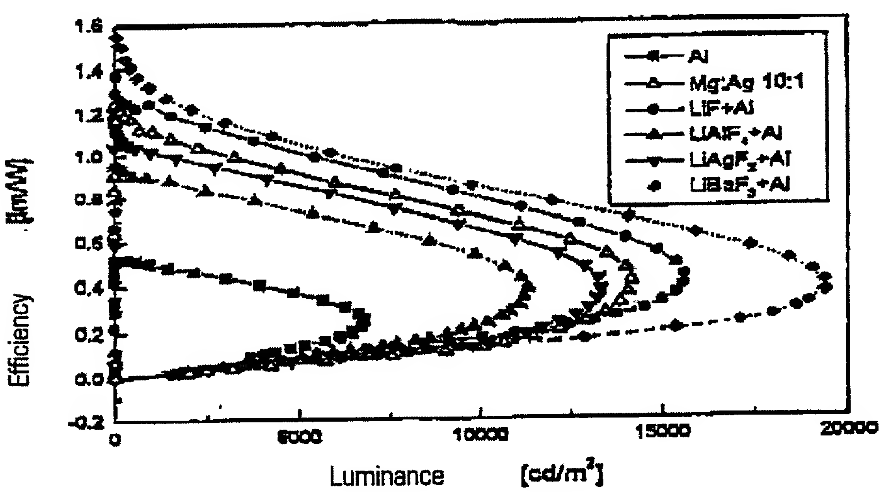
Efficiency [lm/W]
Luminance [cd/m²]
Al
Mg:Ag 10:1
LiF+Al
LiAlF₄+Al
LiAgF₂+Al
LiBaF₃+Al

FIG 4

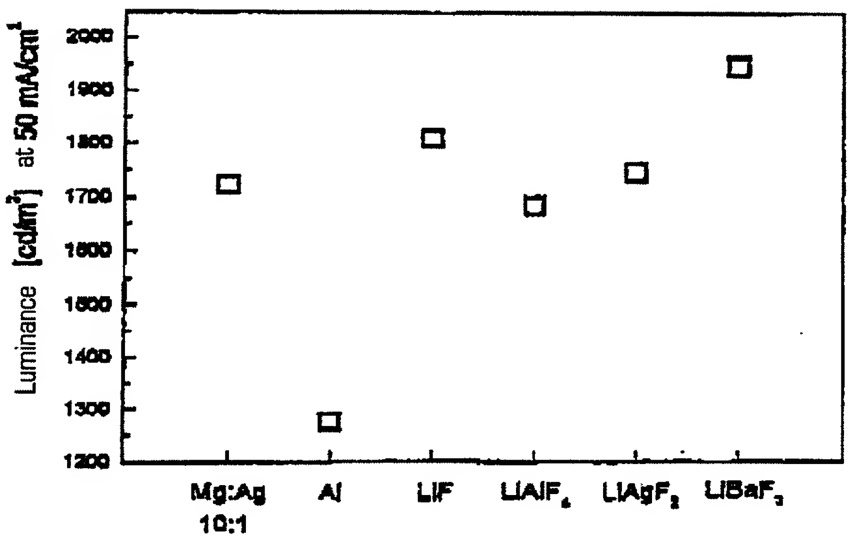
Luminance [cd/m²] at 50 mA/cm²
2000
1900
1800
1700
1600
1500
1400
1300
1200
Mg:Ag
10:1
Al
LiF
LiAlF₄
LiAgF₂
LiBaF₃

FIG 5

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY (Includes Reference to PCT International Applications)	ATTORNEY'S DOCKET NUMBER P01,0300

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name, I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

ORGANIC ELECTROLUMINESCENT COMPONENT

the specification of which (check only one item below):

☒ is attached hereto.

☐ was filed as United States application Serial No. ______

on ______,

and was amended

on ______(if applicable).

☒ was filed as PCT international application

Number PCT/DE00/00783

on March 13, 2000,

and was amended under PCT Article 19

on ______(if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:

COUNTRY (if PCT indicate "PCT")	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 USC 119
Germany	199 13 350.6	March 24, 1999	☒YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO

Combined Declaration For Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications)	ATTORNEY'S DOCKET NO. P01,0300

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject mater of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56 which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120:

U.S. APPLICATIONS			STATUS (Check one)		
U.S. APPLICATION NUMBER		U.S. FILING DATE	PATENTED	PENDING	ABANDONED
PCT APPLICATIONS DESIGNATING THE U.S.					
PCT APPLICATION NO	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED (if any)			

And I hereby appoint all Attorneys Identified by United States Patent & Trademark Office Customer Number 26574, who are all members of the firm of Schiff Hardin and Waite.
Telephone 312/-258-5500 Patent Department
my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

Send Correspondence to: Schiff, Hardin & Waite Atten: Patent Department 6600 Sears Tower, Chicago, illinois 60606 -6473 Customer Number 26574	Direct Telephone Calls to: 312/258-5781

201	FULL NAME OF INVENTOR	FAMILY NAME Kanitz	FIRST GIVEN NAME Andreas	SECOND GIVEN NAME
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	POST OFFICE ADDRESS	POST OFFICE ADDRESS Nackendorf 27	CITY D91315 Hoechstadt	STATE & ZIP CODE/COUNT Y Germany
202	FULL NAME OF INVENTOR	FAMILY NAME Stoessel	FIRST GIVEN NAME Matthias	SECOND GIVEN NAME
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	POST OFFICE ADDRESS	POST OFFICE ADDRESS ~~Aeussere Tennenloher Strasse 47~~ PAUL-MARTIN-UFER 52	CITY ~~D91058 Erlangen~~ D68163 MANNHEIM	STATE & ZIP CODE/COUNTRY Germany
203	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY

MS 10-10-01

MS 10-10-01

I hereby declare that all statements made herein of my own knowlecge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202 X Matthias Stoessel X	SIGNATURE OF INVENTOR 203
DATE	DATE 10-10-01	DATE

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY
(Includes Reference to PCT International Applications)

ATTORNEY'S DOCKET NUMBER
P01,0300

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name, I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

ORGANIC ELECTROLUMINESCENT COMPONENT

the specification of which (check only one item below):

☒ is attached hereto.

☐ was filed as United States application
Serial No. ______________________

on ______________________,

and was amended

on ______________________(if applicable).

☒ was filed as PCT international application

Number PCT/DE00/00783

on March 13, 2000,

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on ______________________(if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

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			☐ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO

Combined Declaration For Patent Application and Power of Attorney **(Continued)** (Includes Reference to PCT International Applications)	ATTORNEY'S DOCKET NO. P01,0300

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U.S. APPLICATIONS			STATUS (Check one)		
U.S. APPLICATION NUMBER		U.S. FILING DATE	PATENTED	PENDING	ABANDONED
PCT APPLICATIONS DESIGNATING THE U.S.					
PCT APPLICATION NO	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED (if any)			

And I hereby appoint all Attorneys Identified by United States Patent & Trademark Office Customer Number 26574, who are all members of the firm of Schiff Hardin and Waite.

Telephone 312/-258-5500 Patent Department

my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

Send Correspondence to:	Direct Telephone Calls to:
Schiff, Hardin & Waite Atten: Patent Department 6600 Sears Tower, Chicago, Illinois 60606 -6473 Customer Number 26574	312/258-5781

201	FULL NAME OF INVENTOR	FAMILY NAME Kanitz	FIRST GIVEN NAME ~~Andreas~~	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Hoechstadt	STATE OR FOREIGN COUNTRY Germany	COUNTRY OF CITIZENSHIP Germany
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Nackendorf 27	CITY D91315 Hoechstadt	STATE & ZIP CODE/COUNT Y Germany
202	FULL NAME OF INVENTOR	FAMILY NAME Stoessel	FIRST GIVEN NAME ~~Matthias~~	SECOND GIVEN NAME
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	POST OFFICE ADDRESS	POST OFFICE ADDRESS Aeussere Tennenloher Strasse 47	CITY D91058 Erlangen	STATE & ZIP CODE/COUNTRY Germany
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	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
Andreas Kanitz		
DATE October/01/2001	DATE	DATE